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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM FOR THE

NEW YORK MEETING

FEBRUARY 27-28, 1925

JOINT MEETING WITH THE OPTICAL SOCIETY OF AMERICA

AT COLUMBIA UNIVERSITY

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The American Physical Society

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FEBRUARY 14, 1925 Vol. 1, No. 1*

BULLETIN

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AMERICAN PHYSICAL SOCIETY

NEW YORK MEETING, FEB. 27-28, 1925

JOINT MEETING WITH THE OPTICAL SOCIETY OF AMERICA

The 131st regular meeting of the American Physical Society will be held in New York City in Fayerweather Hall, Columbia University, on Friday and Saturday, February 27 and 28, as a joint meeting with the Optical Society of America. The first session will be of the Optical Society beginning at 10 o'clock on Friday morning.

Arrangements have been made for members of the two societies to dine together informally at the Faculty Club on Friday evening. Those wishing to do so are requested to notify the Secretary as early as possible on Friday afternoon.

For the titles and abstracts of papers from the Optical Society, see the program of that Society, a copy of which is being mailed to all members of the Physical Society under separate cover. Titles and abstracts of the papers from the American Physical Society are given in the following pages. These latter abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at Corning, New York.

CALENDAR

Friday morning at 10 o'clock. Session of the Optical Society.

Friday afternoon at 2 o'clock. Joint session of the two societies. Papers 1-13.

Saturday morning at 10 o'clock. Joint session of the two societies. Papers 14-22.

Saturday afternoon at 2 o'clock. Session of the Physical Society. Papers 23-37. The supplementary papers beginning with No. 38 will be called for on Saturday if time permits.

Other meetings for the current season are as follows:

132. March 7, 1925. Pasadena.
133. April 24-25, 1925. Washington.
134. June 18-19, 1925. Portland, Oregon, with the Pacific Division of the A.A.A.S.
135. November 27-28, 1925. Chicago.
136. December 28-31, 1925. Kansas City. Annual Meeting.

HAROLD W. WEBB,
Secretary.

* The present bulletin is not a continuation of the Bulletin of the American Physical Society which was first published in 1899 but discontinued after a few numbers.

PROGRAM

FRIDAY MORNING AT 10 O'CLOCK

Session of the Optical Society of America.

(For titles and abstracts see the program of that Society.)

FRIDAY AFTERNOON AT 2 O'CLOCK

Joint session with the Optical Society of America.

Papers preceded by an asterisk (*) are contributed by the Optical Society. For abstracts of these papers see the program of that Society. The presentation of papers in this session is limited to ten minutes.

The presentation of papers will be suspended at 3 o'clock when a lecture will be given by PROFESSOR M. SIEGBAHN of Upsala, Sweden, entitled "X-Ray Spectra and Optical Spectra."

*1. **The static atom.** WILLIAM MAYO VENABLE, Blaw Knox Company.

*2. **Chromatic visibility coefficients by the method of least squares.** DEANE B. JUDD, Cornell University.

*3. **Some tests on the accuracy of measurement with the rotatory dispersion colorimetric photometer.** K. S. GIBSON, Bureau of Standards.

4. **The refractive index of an excited gas.** W. H. M. CURDY, Princeton University. —According to the quantum theory of dispersion advanced by Born and Kramers, anomalous dispersion should occur near both emission and absorption lines of an excited gas. To test this, an He discharge tube has been placed in one arm of an interferometer. As a source of light an iron arc resolved by means of a monochromatic illuminator has been used. When light of frequency near that of an He line was incident on the interferometer, it was possible to determine the change in optical path by the fringe shift on striking the arc, and thus determine the contribution to the refractive index of atoms in certain states of excitation. Lines 5047 and 5016 showed a fringe shift of from 1/4 to 1/3 of a fringe when light of about 2 A separation from the He lines was used. Lines 4471, 4120, 4143 are being studied photographically. When light of frequency of large separation from any He line is used no shift can be observed on striking the arc.

*5. **Polarization and deviation from Lambert's Cosine Law for light emitted by tungsten, tantalum and molybdenum at incandescence.** A. G. WORTHING, Nela Research Laboratory.

*6. **Spectrophotometric measurements of certain iridescent colors.** ERNEST MERRITT, Cornell University.

7. A relation between the critical potentials and the indices of refraction of elements and compounds. BERGEN DAVIS, Columbia University.—Recent experiments of Davis and von Nardroff (Proc. Nat. Acad. Sci., **10**, 60, 9, 1924) show that the Lorentz dispersion formula represents the refraction of x-rays very well. The frequencies used were the critical x-ray frequencies. This formula is now applied to refraction of visible light (λ5893) in elements and compounds. The critical frequencies are calculated from critical potentials. For example, the mean critical potential of hydrogen is 16.4 volts (16 and 16.9); this gives the index of refraction of hydrogen very accurately. The same is true for critical potentials and indices for zinc, cadmium and mercury. The same critical frequencies that give proper indices for nitrogen, oxygen, sulphur, chlorine, bromine and iodine also give the proper indices for their compounds. The energy of the heat of formation of compounds is added to that of the valence electrons. For example, for water the index calculated without using the heat of formation is $n=1.372$. Adding this heat energy to that of the valence electrons of the hydrogen, gives the value 1.338 for the index. The observed index is 1.333. By interpolation between lithium and oxygen, a critical potential of carbon (all in the same series) may be inferred, which gives the proper index for carbon compounds. Including the heat of formation of diamond, the critical potential of carbon also gives a value close to the observed index.

***8. Excitation of forbidden spectral lines.** PAUL D. FOOTE, T. TAKAMINE, R. L. CHENAULT, Bureau of Standards.

***9. Empirical dispersion formulas for optical glasses.** F. E. WRIGHT, Geophysical Laboratory.

***10. Gray skies and white snow.** IRWIN G. PRIEST, Bureau of Standards and Munsell Research Laboratory.

11. The arc spectra of silver and copper. A. G. SHENSTONE, University of Toronto.—The ultra-violet spectra from low-voltage arcs in silver and in copper vapour have been photographed. No lines, except the first two pairs of the principal series, were obtained in silver. With copper, thirty-nine lines were photographed. Of these, ten were calculated to be due to terms combining with $1s$. Absorption experiments confirmed this calculation. The terms obtained combine either with md_2, called X by Fowler, or with md_2 and with md_1, which has a value 51105.5. The inner quantum numbers obtained from these combinations indicate two pairs of inverted p terms with wide separations, two pairs of p terms in the normal order, and two apparently single terms of inner quantum number 2. Seven further possible terms have been calculated which combine with s terms; and five which combine with md_1 and md_2 only.

12. Optical constants of tungsten at incandescence and at room temperature. A. G. WORTHING, Nela Research Laboratory.—Two broad, polished, well-seasoned tungsten ribbons mounted as lamp filaments in lamp bulbs were used for this test. The method was photometric, all measurements being made with a disappearing filament pyrometer sighted through a double image prism at the filaments being studied. With a filament at incandescence, the polarized brightness components B_s and B_p for normal emission and for large emission angles (75° to 83°) were determined. Using previously measured spectral emissivities, the reflectivities r_s and r_p at these large emission angles were then obtained. The angle for which r_s/r_p is a maximum was identified with the angle of principal incidence; and values for n, the refractive index, and nk, the extinction coefficient, were finally computed. With the filament at room temperature, r_s and r_p were

measured directly. A single very consistent set at room temperature yielded ($\lambda = 0.665\mu$) $n = 3.82$ and $nk = 3.05$; the average of four sets at 1900°K yielded $n = 3.85$ and $nk = 3.43$. While the uncertainties are such as to make it doubtful whether or not n varies, there is certainty about the variation in nk with temperature.

13. Radial astigmatism in light reflected at an angle from spherical mirrors. R. J. PIERSOL, Westinghouse Elec. and Mfg. Co.—Using the zone method, Silvanus Thompson has checked experimentally empirical calculations for coma in the complex case for lenses. For coma due to light reflected at an angle from a spherical concave mirror it is found possible to work out theoretical relations. These equations show that: (1) The distance from the mirror to the circle of least confusion is independent of the angle of incidence. (2) For parallel light this distance is the principal focal length of the mirror. (3) The ratio in the case of parallel light of the diameter of the circle of least confusion to the diameter of the mirror is equal to (1—cos θ). (4) The ratio of the meridian focal length to the sagitta focal length is equal to $\sec^2 \theta$.

SATURDAY MORNING AT 10 O'CLOCK

Joint session with the Optical Society.

The papers presented at this session are contributed by the Physical Society. The presentation of papers will be suspended at 11 o'clock and two lectures will be given by invitation of the Optical Society, as follows:

The Properties of Photographic Materials in Relation to Their Use in Physical Measurements. C. E. K. MEES, Eastman Kodak Company.

The Eye as a Light Sensitive Instrument. W. T. BOVIE, Harvard University.

14. Modifications of Lichtenberg figures by suspended electrodes. HAROLD P. KNAUSS, New York University.—When a conductor supported at a height of about 5mm above a photographic plate is suddenly raised to a high potential, a design is produced which differs from the ordinary Lichtenberg figure caused by an electrode in contact with the plate. When the electrode is positive, the design is made up of many small spots with radiating arms; when negative, a circle of spots appears with fine lines radiating from the circle. A series of exposures was made with varying distances, showing that the characteristics changed gradually from the ordinary figures to the modified figures. The electrode produced effects at greater distances when negative than when positive. Various other modifications in the figures caused by changing the relative position of the plates and the electrodes were studied.

15. Vapor pressure of mercury at low temperatures. F. E. POINDEXTER, Washington University.—The vapor pressure of mercury was measured with a Buckley ionization gauge at intervals of 7° to 10° from 20°C to −65°C. Observations on different days agreed to less than one percent down to −35°C. The agreement was not so good from −48° to −65° since the positive ion current corresponding to the vapor pressure at these temperatures gave only a few mm deflection. The pressure at −65°C was of the order of 10^{-8} mm. A platinum resistance thermometer of approximately 25 ohms resistance and calibrated at the steam, ice, and oxygen points was used to measure the temperatures.

16. Properties of thorium metal. H. C. RENTSCHLER and J. W. MARDEN, Westinghouse Lamp Co., Bloomfield, N. J.—Coherent thorium of high degree of purity has been prepared. The metal is workable and pliable and can be rolled, drawn and worked cold. Its melting point is 2115° K ±30°. The volatility is very low even at or near the temperature at which it melts. It has a density of 11.3 to 11.7, depending on the amount of working to which the metal has been subjected. The average coefficient of linear expansion between zero and 100°C is 12.3×10^{-6}. Cold worked wire has a tensile strength of about 80,000 lb. per square inch and a resistivity at room temperature of about 18×10^{-6} ohm-cm, with an average temperature coefficient of resistance between room temperature and its melting point of about .0021.

17. Multiple resonance points in oscillating systems. PAUL HEYMANS, W. H. DEHLINGER and M. S. VALLARTA, Massachusetts Institute of Technology.—Heymans and Kimball found, in their study of dynamical stresses by the photo-elastic method, evidence of multiple resonance caused by excitations having frequencies which are nearly integral multiples of the natural fundamental frequency. H. Fletcher evidenced the same effect when he found that the elimination of the fundamental and several overtones does not alter the pitch of a musical tone. The authors of this paper present an analysis of these resonance phenomena based on the solution of the dynamic equation of motion $\ddot{y}+a\dot{y}+\sum_m p_m y^m = Ae^{i\nu t}$ showing that multiple resonance points exist provided the elastic connections are such as to satisfy the relation $p_m = m^2\omega_0^2+a^2/4$, where $m=1, 2, 3 \ldots$ and ω_0 is the fundamental natural frequency. The kinetic equation of free motion is then $y=\sum_m P_m e^{(im\omega_0-\delta_0)t}$ and resonance is obtained for all frequencies $\nu = m\omega_0$ which are integral multiples of the fundamental frequency. The amplitudes at the resonance points for forced oscillation vary with the harmonic order of the applied frequency. For small values of $a/m\omega_0$ the amplitudes at resonance follow a linear law, expressed by $Q_R = Q_0\omega_0 m/a+3Q_0/4$. For all other points the amplitude is given by $Q=Q_0k^2(1/2z^2-\pi\cot\pi z/2z)$ where $z^2=k^2\text{-}iak/\omega_0$ and k is ν/ω_0.

18. Some remarks on the diamagnetism of gases at low pressures. P. DEBYE (Zürich), Massachusetts Institute of Technology. (introduced by Paul Heymans.)—According to the experiments of Glaser, the diamagnetic susceptibility of some gases is proportional to the pressure only for small and large pressures, the coefficient of proportionality dropping in the ratio 3:1 in the domain of transition. A possible explanation is put forward in connection with the viewpoint that for small pressures we may have a quantum-effect of orientation, disturbed at higher pressures by the action of molecular forces. A rough estimate of the order of magnitude of the forces, which may act on the molecules seems to give indeed a quantitative support of the idea, in so far as it leads to an approximate calculation of the pressure in the transition domain. Some remarks are added regarding a possible analogous behavior of the dielectric susceptibility.

19. On the aberration of light. LEIGH PAGE, Yale University.—Writers on relativity treat the problem of annual aberration by comparing the inertial system of the earth with that of the sun. As the phenomenon is due entirely to the change in velocity of the observer, the introduction of the system of the sun is unnecessary and only confuses the issue. The following expression for the aberration $\alpha-\alpha'$ is deduced from the relativity theory without reference to the system of the sun: $\sin\frac{1}{2}(\alpha-\alpha^1) = (1/\beta)[1-(1-\beta^2)^{\frac{1}{2}}]\sin\frac{1}{2}(\alpha+\alpha^1)$. In this formula β is the ratio of the magnitude of the change in the velocity of the earth to the speed of light. The expression is symmetrical in the two observed positions of the star, α and α'.

20. Bohr's atomic model from the standpoint of general relativity. M. SANDOVAL VALLARTA, Massachusetts Institute of Technology.—Examining Lenard's objections to Sommerfeld's theory of fine structure, it is found that neither the restricted nor the general theory stand in a unique causal relationship to the theory of fine structure, hence that one of the objections holds. Using Nordström's fundamental form for a static sphero-symmetrical material field and Weyl-Eddington's equation of electronic motion, it is shown, first, completing Jaffé, that in the hydrogen atom and all hydrogenic ions: (1) the curvature of the material field of the nucleus almost vanishes, (2) its field is very nearly static, (3) it is justified to treat such atom and ions as a relativistic one-body problem; second, that in such cases the general equation of the electronic orbit reduces to Sommerfeld's equation. In an attempt to bring the quantum theory into relativity, following Mecke's, some of the former's fundamental principles are brought into the latter, leading to (1) an explanation of the existence of unmechanical orbits in atoms of more than one electron, (2) a unification of Bohr's frequency postulate and Correspondence Principle—whereas the Sommerfeld-Wilson conditions require the introduction of privileged coordinates. The fundamental meaning of the relativistic two-body problem in connection with the theory of stationary orbits is brought out.

21. The influence of an electrostatic charge upon metallic conductivity. HENRY A. PERKINS, Trinity College.—Observations on the effect of a static charge on the conductivity of sputtered gold films was described in the August issue of the Journal de Physique, 1923. The result was negative, but a graphite film gave positive results indicating a decrease of conductivity with a negative and an increase with a positive charge. These experiments were continued last Spring using a very thin sputtered film of bismuth. When charged negatively to 600 volts it showed an increase in resistance of about .020 percent, and with a positive charge at the same potential there was also an increase, but only about .017 percent. This behavior was fairly consistent under varying conditions, seeming to indicate the presence of two phenomena, one of them reversible. The irreversible increase of resistance may be due to something analogous to the well known effect of magnetism on bismuth, but caused, in this case, by a transverse deflection of the free electrons; while the reversible charge seems similar to that noted above in the case of graphite, but much smaller. An alternating field produced an increased resistance intermediate between the two other values cited.

22. A method for obtaining a linear time axis for use with a cathode ray oscillograph. AUSTIN BAILEY, Department of Development and Research, American Telephone and Telegraph Company.—One way to obtain a voltage for deflecting the spot of a cathode ray tube linearly with time, is to charge a condenser repeatedly through some device which will maintain the charging current constant, since, from the equation for charging a condenser, $E=Ir+(I/C)\int dt$, we obtain $r=R_0-t/C$. Various arrangements for doing this have been proposed. The author's method is to connect a battery, condenser and saturated thermionic rectifier in series, the condenser being shunted with a neon tube. It has been shown by S. O. Pearson and H. St. G. Anson (Phy. Rev. **34**, 204, 1922) that the voltage at which such a neon tube breaks over is very definite, and that it continues to carry current until the voltage across it has fallen below another very definite voltage limit, where the tube is extinguished. The condenser is hence charged linearly with time through the constant current saturated thermionic rectifier and then discharged very quickly through the neon tube. By connecting one pair of deflecting plates of the cathode ray tube between the filament and plate of the thermionic rectifier, a deflection of the spot in the cathode ray tube occurs linearly with time and returns very rapidly to its initial position, from which point the cycle is repeated at a constant frequency.

SATURDAY AFTERNOON AT 2 O'CLOCK

Session of the Physical Society.

23. The two stage transformation of magnetite into hematite. LARS A. WELO, and OSKAR BAUDISCH. The Rockefeller Institute for Medical Research.—It has been found that the powdered ferro-ferric oxide Fe_3O_4 (magnetite) can be completely oxidized in a stream of oxygen to Fe_2O_3 (hematite) at a low temperature of 220°C and may yet retain its maximum permeability of 2.85. Then, if this ferric oxide is subsequently heated in a neutral atmosphere of, say, nitrogen at 550°C the maximum permeability falls to 1.05. The practically total loss of ferro-magnetism is therefore purely a temperature effect. But the necessary condition is that the ferrous iron in Fe_3O_4 must first be oxidized to the ferric form. If Fe_3O_4 is not first oxidized it may be heated in the absence of oxygen to at least 800°C without permanent loss of permeability. The crystal structure also changed on the second stage; that is, the oxide Fe_2O_3 had the same structure as Fe_3O_4 and did not assume the structure usually found for Fe_2O_3 until the temperature of 550°C had been reached. It is concluded that an oxide of the composition Fe_2O_3 can have two structures, one being that of Fe_3O_4, provided it has never been heated to 550°C or more. Three independent tests have been made to meet the possible objection that the first stage results only in surface oxidation and that the cores of the particles remain Fe_3O_4 until a higher temperature is reached.

24. Crystal structure of chromium and titanium. R. A. PATTERSON, Rensselaer Polytechnic Institute.—Precision measurements of the crystal structure of these two metals in very pure form have been made. For chromium (99.8 percent) a body centered cubic structure, $a_0 = 2.872$ A, is found; for titanium (99.9 percent), an hexagonal close-packed structure, $a_0 = 2.92$ A; axial ratio $c = 1.60$. These structures are of the type previously assigned by A. W. Hull, but differ slightly in numerical values. They were measured in comparison with copper, using Davey's value of $a_0 = 3.598$ A for pure copper.

25. The crystal structure of cold-worked and burnished metals. J. T. NORTON and R. J. ANDERSON, Massachusetts Institute of Technology.—Examination of the surfaces of cold-worked and heavily polished metals by means of the x-ray spectrograph indicates that the surfaces have a definite crystalline structure and there is no evidence of an amorphous state. Severely cold-worked metals, reduced as much as 98 percent in area, as well as polished surfaces of annealed metal and large single metal crystals give diffraction patterns which are typical of fine grained material. In the case of polished surfaces, the typical pattern may be destroyed by etching, and the pattern which is characteristic of the body of the metal results. The size of the crystal grain is determined in a general way from the appearance of the lines of the diffraction pattern. The conclusion is drawn, on the basis of x-ray evidence that metals are fragmented on cold-work and polishing, and are not amorphized.

26. An experimental determination of the true absorption of hard x-rays in water. HUGO FRICKE, OTTO GLASSER and KARL ROTHSTEIN, Cleveland Clinic Foundation.—The coefficient of true mass absorption of a substance is determined by the following equation: $\mu = (1-\alpha)/(1+\alpha) \int I_x dx$, in which α expresses that fraction of the intensity of an infinitely wide bundle of parallel x-rays, which is reflected from a plane surface of the substance and I_x is the ratio of the x-ray intensity x cm under the surface to the intensity at the surface. The x-ray intensity was measured by an ionization chamber of graphite

of a volume of 1 cc. For nearly homogeneous x-rays of the effective wave-length $\lambda_{eff}=.14$A we find as preliminary values $a=.57$ and $\int I_x dx=10.7$, $\mu=.0256$ (accuracy of μ is about 10 per cent). A value of $\mu=.0279$ is obtained as the sum of a photo-electric absorption equal to .0064 and a scattered absorption equal to .0215, in accordance with Compton's theory.

27. Longitudinal asymmetry in the direction of ejection of photo-electrons by x-rays. O. K. DEFOE, Washington University.—Photo-electrons were ejected from moist air in a Wilson cloud expansion apparatus by unpolarized x-rays from a Coolidge tube with a Mo target. The tube was operated at 30 kv peak and the rays were made approximately homogeneous of wave-length 0.71 A by filtering through a zirconium phosphate screen. The direction of ejection was determined by means of stereoscopic photographs taken at right angles to the beam of x-rays. Careful count showed that about 20 percent of the tracks were at 90° to the beam, while nearly all the tracks were within 45° of the plane normal to the beam. The experimental value of the ratio of the forward to the backward photo-electrons was 2.89. Bubb (Phys. Rev. **23,** 289) gives the theoretical value of the ratio as $(\lambda+.110\sqrt{\lambda_0})/(\lambda-.110\sqrt{\lambda_0})$, where λ is the wave-length of the x-rays and λ_0 is the critical K ionization wave-length of the atom from which the ejection takes place. The percentages of tracks of photo-electrons from N, O and A atoms are obtained from the lengths of the tracks. These give the average theoretical value of the ratio as 3.08.

28. The effect of x-rays in producing and modifying thermo-luminescence. FRANCES G. WICK, Vassar College.—Exposure to x-rays produces marked changes in the thermo-luminescence of many substances and gives this property to some inactive materials. Thermo-luminescence due to x-rays appears at a lower temperature and usually has a higher intensity than that which the same substances show before exposure. In some cases the color is different from that in the natural specimen and comes up as a distinct flash at a lower temperature. Several fluorites and calcites were studied in detail. Comparison was made of the rate of decay at constant temperature of the thermo-luminescence of the natural material with that of the same substance after exposure to x-rays and also with that of the same substance heated to render it inactive before exposure to x-rays. Decay curves were taken after exposure for different lengths of time and at various temperatures. The curves are, in general, similar to those characteristic of phosphorescent materials. The form is that of the "persistent type" at comparatively low temperatures and gradually changes over to the "vanishing type" as the temperature is raised. Observations were made upon specimens which had rested for various intervals of time after exposure and upon specimens exposed at the temperature of liquid air.

29. Sparking potentials of helium, neon and argon at reduced pressures between plane parallel electrodes of pure aluminium and of potassium-coated aluminium. C. C. VAN VOORHIS, Princeton University. (Work done in the Westinghouse Lamp Company Research Laboratory.)—The sparking potentials of helium and neon at pressures between 3 and 25 mm and of argon between 1 and 15 mm were determined for electrode separations of from 2 to 5 mm. With pure aluminium electrodes Paschen's Law holds for pressures greater than about 9, 12 and 3 mm for helium, neon and argon, respectively (values will be given for the three gases in this order throughout); and for the minimum striking potentials the values of pd (pressure in mm times electrode separation in mm) are about 35, 38 and 12. With potassium coated electrodes the pressures must be not less than about 6, 6.5 and 1.5 mm for Paschen's Law to be valid and the values of pd for the minimum striking potentials are about 24, 20 and 5.3. For pressures above the limiting values, and values of pd above those for the minimum sparking potentials, the equations $V_{He}=127+57\ pd$, $V_{Ne}=149+.5\ pd$ and $V_A=173+$

1.6 *pd* give fairly accurately the sparking potentials between aluminium electrodes, and $V_{He}=70+.31\ pd$, $V_{Ne}=68+.33\ pd$ and $V_A=58+2.3\ pd$ those between potassium-coated electrodes.

30. The distribution of initial velocities among thermionic electrons. L. H. GERMER, Bell Telephone Laboratories, Inc.—The initial distribution of velocity components among thermionic electrons from tungsten has been carefully investigated. The method was similar to that devised by Schottky in that measurements were made of the current to a cylindrical electrode from a coaxial tungsten filament. Various refinements in the experimental technique have made measurements possible over a very wide range of temperatures and voltages. It has been found that the results are entirely in agreement with the assumption that thermionic electrons are emitted from tungsten with components of velocity distributed according to Maxwell's law for an electron atmosphere in thermal equilibrium with the hot filament. The temperature range investigated extended from 1440°K to 2475°K, and at one temperature the assumed law was verified to a potential corresponding to an electron speed possessed by only one electron in 10^{10} emitted electrons. Later measurements in this laboratory have shown that the same law holds for the thermionic electrons emitted from oxide-coated platinum filaments.

31. Production of negative ions by electron collisions with molecules. F. L. MOHLER, Bureau of Standards.—A beam of electrons is projected along the axis of a cylindrical electrode in a nearly equipotential region with a magnetic field of about 100 gauss parallel to it. This prevents scattered electrons reaching the cylinder so that when it is slightly positive or negative, only negative or positive ions produced by electron collisions reach it. Measurements in Hg, $HgCl_2$, I_2 and HCl show in all cases with low pressure (about .001 mm) and small electron current no negative ion current comparable with the positive current above the ionization potential. With higher pressures the negative currents increase to the magnitude of the positive currents and there is, except with mercury, a measurable current for all electron velocities. With increasing speed the ion current first drops and then increases at certain critical voltages which are presumably potentials of inelastic collision. The results indicate that polar molecules are not ionized into positive and negative ions by electron impact and that only slow moving electrons combine with molecules to form negative ions.

32. The photo-electric effect in potassium vapor. ERNEST LAWRENCE, Yale University.—The results of an experimental investigation of the photo-electric effect in potassium vapor presented at the Washington meeting have been confirmed by recent experiments. Of outstanding interest perhaps is the evidence of a photo-electric threshold at 2610 A, a value in distinct disagreement with the critical frequency 2856 A which the Bohr theory suggests as the threshold. Ionization by ultra-threshold frequencies per unit intensity of light increases with the frequency. The present results are in complete accord with the former ones and appear to be independent of such experimental conditions as the density of the vapor, and the fields between the electrodes.

33. Collisions of the second kind in monatomic iodine. H. D. SMYTH, Princeton University.—Several experiments have furnished strong indirect evidence for the existence of the "collisions of the second kind" first suggested by Klein and Rosseland. There appears a possibility of a somewhat more direct observation of the phenomenon in monatomic iodine. A neutral iodine atom has an electron affinity of 3.5 volts. That is, during the formation of a negative ion, 3.5 volts energy must be released and the binding of the extra electron may proceed through various stages of excitation like those in the familiar recombination process of an electron and positive ion. If, therefore, a second free electron approaches such a system, a collision of the second kind may occur causing the

electron to fly off with speed not greater than 3.5 volts. The advantage of such a system for an experimental test of the phenomenon is that no electrons of speeds greater than a volt or two need be present originally. Preliminary results of experiments done in a pyrex tube with three electrodes and at about 600°C indicate that high speed electrons are produced, apparently in two groups, one corresponding to a gain in velocity of about three volts and another of about five volts. The experiments will be continued.

34. Critical potentials in secondary electron emission from iron. ROBERT L. PETRY, Princeton University.—The secondary electron emission from an iron target bombarded by electrons from a tungsten filament was measured as a function of the bombarding voltage. Both currents were measured by a null method of high precision and elaborate precautions were taken to avoid disturbing factors. The target was cleaned by heating to a red heat. The secondary emission rose to a maximum at about 410 volts and fell gradually to 74 per cent of this maximum value at 1500 volts. Critical potentials were located at 6.7, 9.0, 13.85, 26, 34, 39, 42.8, 48.3, 54.6, 66.7, 80.5, 92.7, 740, 810, and 1010 volts and several others are being investigated. There is a close agreement with critical potentials for soft x-rays at the lower voltages but above about fifty volts the agreement is less satisfactory. The interpretation of the curves is discussed.

35. Direction finding and the Heaviside layer. R. C. COLWELL, West Virginia University.—During the day wireless direction finders show only a very small error but at night they are extremely erratic. If the received signal by day consists only of the wave which travels over the surface of the earth while at night an additional wave is received by reflection from the Heaviside layer, it can be shown that an error in direction is given by $\tan B = (I_D - I_R \cos\theta)/(I_R \sin\alpha \cos\alpha \sin\theta)$, where $(90-B)$ is the angle of error and θ the angle through which the plane of polarization of the reflected beam is rotated: α is the angle that the reflected beam makes with the vertical. Close to the antenna α is small, therefore the error of direction is small for short distances even at night. At very great distances α approaches 90° so that $\cos\alpha$ is small—hence the directional errors tend to disappear at very great distances (2000 to 3000 miles).

36. The dependence of radio fading on modulation. G. BREIT, Department of Terrestrial Magnetism, Carnegie Institution of Washington.—The phenomena of radio fading are presumably due to the interference of waves produced by reflections from the Heaviside layer. It is of interest to note that by a simple calculation one can show that the interference phenomena produced depend on the modulation of the signals and that, therefore, data on radio fading cannot be used for inferences as to the layer before the effect of the modulation is taken into account. The reason for this effect is the comparatively high resolving power of the interferometer formed by the layer and the earth which superposes the "dark" and "bright" bands of the wave-lengths in the emitted band. This fact has been recently observed by G. W. Pickard and may give a way of estimating the height of the layer.

37. On the theory of diamagnetism. S. J. BARNETT, The Carnegie Institution of Washington and the California Institute of Technology.—The Weber-Langevin theory (1) and that of Pauli based on Larmor precession (2) are first discussed. The intensity of the magnetic field will be denoted by H. (1) gives a band for the Zeeman effect; (2) the sharp lines as is known. The susceptibilities, K_1 and K_2, are different except when the orbits are normal to H. When they are parallel to H, K_1 vanishes. The ratio of susceptibility K_R for random orientation of the orbits to that (K_P) for similar orientation (axes parallel to H) is 1/3 by (1), and 2/3 in the simplest case by (2). In the general case of (2), K_R/K_P (where K_P corresponds to orientation with a principal axis parallel to H) is 2/3×total "quadrupolmoment"/quadrupolmoment normal to H. H is shown to

orient diamagnetic atoms, which tend to set with the extraneous flux through the orbits a minimum. The general law is similar to that developed by Langevin for magnetic double-refraction, alignment approaching completeness and susceptibility a minimum asymptotically as H increases and temperature decreases. This cannot explain the recent results of Glaser which, it is suggested, may possibly be due to a quantization resulting from the weak magnetic moment produced according to (1) or (2) in an intense field.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session after the completion of the regular program for the session.

38. The Heaviside layer and night reception. R. C. COLWELL, West Virginia University.—It is assumed that the Austin-Cohen formula gives correct quantitative results for wireless reception by day and that the increased signal strength at night is caused by multiple reflections from the Heaviside layer. With these assumptions an equation for the reception of signals is developed in the form: $I_R = \left[377\ I_s h_s h_r / R\lambda\right] \left[e^{-.0015x/\sqrt{\lambda}}(1-e^{-.0015x/\sqrt{\lambda}})\ (\sigma+\sigma^2+\sigma^3+\ \ldots)\right]$ where σ depends upon the reflective power of the Heaviside layer. As the reflective power of the Heaviside layer changes, the signal strength will vary but always between the limits $377\ (I_s h_s h_r/R\lambda)$ and $377(I_s h_s h_r/R)\ e^{-.0015x\sqrt{\lambda}}$.

39. Further measurements of very small intervals of time. PAUL HEYMANS and NATHANIEL H. FRANK, Massachusetts Institute of Technology.—The authors presented at the previous meeting a description of their method for measuring intervals of time from 9×10^{-6} to 3×10^{-10} second. Having since extended it to the measurement of still shorter intervals, they discuss in this paper a series of measurements made for intervals from 4×10^{-9} to 6.6×10^{-11} second. On the photograph registering the shortest interval for a series of measurements the shift of the meeting line of the two Lichtenberg figures from the half-way position between the electrodes was .044 mm, with a mean square error of $\pm$.005 mm and a probable error of $\pm$.003 mm. The introduction of 2 cm of wire in the lead to the "advanced" electrode yielded a shift of the meeting line from the half-way position of .003 mm with a mean square error of $\pm$.011 mm and a probable error of $\pm$.007 mm, indicating return of the meeting line to the half-way position and giving for the interval of time recorded on the previous plate the value 6.6×10^{-11} second. The necessity for precaution in selecting photographic plates of uniform thickness has emphasized itself in the course of those measurements.